Name:_____

Unit 5: Acids and Bases

Practice Exam Chem 30

/ = %

Formulas:

$c = \frac{n}{V}$ $K_w = [H_3O^+] \times [OH^-] = 1.0 \times 10^{-14}$ $pH = -\log [H_3O^+]$

$pOH = -\log [OH^-]$ $14 = pH + pOH$ $K_a \times K_b = K_w$

Common Acid-Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.2 – 4.4	red to yellow
bromthymol blue	6.0 – 7.6	yellow to blue
phenolphthalein	8.2 – 10	colorless to pink
litmus	5.5 – 8.2	red to blue
bromcresol green	3.8 – 5.4	yellow to blue
thymol blue	8.0 – 9.6	yellow to blue

Multiple Choice

1. Which of the following is amphoteric?
   a) HSO_4^-
   b) NH_3
   c) HNO_3
   d) OH^-

2. An Arrhenius acid _____
   a) is an ionic compound which contains oxygen atoms
   b) produces an aqueous solution having a pH more than 7
   c) forms hydrogen ions in aqueous solution
   d) is a neutral molecule

3. A Brønsted acid is defined as _____
   a) an electron pair acceptor
   b) a hydrogen donor
   c) a hydrogen acceptor
   d) a hydroxide acceptor
   e) an electron pair donor

4. A Lewis base is defined as___
   a) an electron pair acceptor
   b) a hydrogen donor
   c) a hydrogen acceptor
   d) a hydroxide acceptor
   e) an electron pair donor

5. Which of the following would you NOT expect to act as Brønsted-Lowry bases:
   a. Br^-
   b. NH^{3-}

c. H_3PO_4

d. H_2O

For the equilibrium: $H_2O + NH_3 \leftrightarrow NH_4^+ + H_3O^+$

6 & 7 List the acid, base, conjugate acid and conjugate base:

8. Which of the following is incorrectly paired with its Brønsted-Lowry conjugate base or conjugate acid?
   a) H_2O, H_3O^+
   b) CH_3COO^-, CH_3COOH
   c) SO_3^{2-} and SO_2
   d) F^-, HF

9. What is transferred between a conjugate acid base pair?

10. The conjugate base pair to the acid HSO_4^- is:

11. A 0.002M H_3PO_4 solution can be described as:
    (weak/strong) (concentrated/dilute) (acid/base)

12. A 0.000020M CH_3COOH solution can be described as:
    (weak/strong) (concentrated/dilute) (acid/base)

13. A 10.0M NH_3 solution can be described as:
    (weak/strong) (concentrated/dilute) (acid/base)

14. You have an unknown acid that you do not know what the concentration is. What would you expect the [OH-] to be in this solution?
    a. Greater than 1.0×10^{-7}M
    b. Greater than 1.0 M
    c. Less than 1.0×10^{-7}M
    d. Less than 1.0M
    e. It is not possible to know from this information.

15. Identify the weakest acid of the following based on their Ka values:
    a. HF: $Ka = 6.7 \times 10^{-4}$
    b. HNO_2: $Ka = 5.1 \times 10^{-4}$
    c. C_6H_5COOH: $Ka = 6.6 \times 10^{-4}$
    d. H_2CO_3: $Ka = 4.4 \times 10^{-7}$

16. Identify the strongest base based on their Kb values:
    a. PO_4^{3-}: $Kb = 5.9 \times 10^{-3}$
    b. CO_3^{2-}: $Kb = 2.1 \times 10^{-4}$
    c. NH_3: $Kb = 1.8 \times 10^{-5}$
    d. N_2H_4: $Kb = 9.5 \times 10^{-7}$

17. A substance is tested using indicators to determine the approximate pH. The substance turns thymol blue yellow, chlorophenol red orange, and bromcresol green blue. Which of the following is a possible pH for this substance?
    a. 3
    b. 6
    c. 7
    d. 8

18. An indicator changes colour at a pH range of 3.8 – 5.4. Which combination below would be best suited for a titration using this indicator?

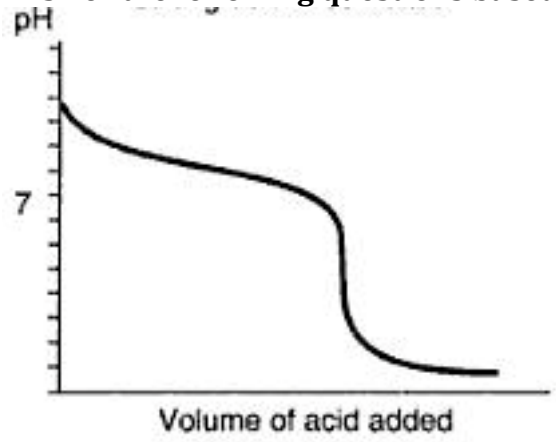
A. HCl and NH_3

B. CH_3COOH and NH_3

C. HCl and CH_3COOH

D. CH_3COOH and $NaOH$

Answer the following questions based on the titration curve shown below.



19. This curve represents a:

a) Strong base being titrated by a strong acid
b) Strong acid being titrated by a strong base
c) Strong base being titrated by a weak acid
d) Weak acid being titrated by a strong base
e) Weak base being titrated by a strong acid
f) Strong acid being titrated by a weak base

20. An appropriate indicator to use for this titration would be:

a) Methyl orange
b) Bromocresol Green
c) Limus
d) Thymol blue

Short Answer:

1. Discuss the limitations of the theories of acids and bases presented by Arrhenius, Bronsted-Lowry and Lewis. (3 marks)

2. Explain how acid-base indicators function chemically, using Le Chatelier's principle. (3 marks)

3. Write the reaction equations for the dissociation of each of the following substances in water and explain, with the use of Brønsted-Lowry reaction equations, the acidity or basicity of the resulting solutions: (4 marks)

   sodium phosphate, weak base

   ammonium chloride, weak acid

4. What is the pH of a solution in which the $[OH^-]$ is 6.0×10^{-4}? (1 mark)

5. What is the pOH of a 1.25×10^{-3} M HCl? (2 marks)

6. What is the hydroxide ion concentration in a 0.50 mol/L solution of sulfuric acid? (3 marks)

7. 15.0 mL of a sulfuric acid solution, required 74.0 mL of a sodium hydroxide solution (0.80 M) to neutralize. What is the concentration of the acid? (3 marks)

8. A student is performing a titration using hydrochloric acid and barium hydroxide according to the following equation:
   $Ba(OH)_2$ (aq) + 2HCl (aq) → $BaCl_2$ (aq) + $2H_2O$ (l)

What volume (in mL) of 0.500 M HCl is needed to neutralize 25.0mL of 3.1M $Ba(OH)_2$? (3 marks)

9. The K_a value for acetic acid is 1.8×10^{-5}, determine K_b for the basic anion, CH_3COO^-. (2 marks)

10. A 1.20 M solution of the weak acid H_2CO_3 has a pH of 4.12. Determine K_a for H_2CO_3 (carbonic acid). *Consider only the first ionization step.* (4 marks)

11. Methylamine is a weak base that is related to ammonia. It has a $K_b = 4.38 \times 10^{-4}$. Calculate the pH of a 0.55 M solution. (5 marks)

Extras that may be added:

26. Which of the following is a conjugate acid-base pair in the reaction $NH_3(g) + H_2O(\ell) \Leftrightarrow NH_4^+(aq) + OH^-(aq)$?

A. H_2O and OH^-
B. H_2O and NH_3
C. H_2O and NH_4^+
D. OH^- and NH_4^+

25. Which substance below is considered a base according to the Brønsted-Lowry theory but not the Arrhenius theory?

A. CH_4
B. NH_3
C. NaOH
D. $Ca(OH)_2$

. Citric acid, symbolized $H_3Ct(aq)$, is a triprotic acid that fulfills a variety of roles. It is used as a food preservative as well as a flavouring agent for foods, beverages, and confections. It is also used to condition water, remove sulfur dioxide from smelter waste, and polish metals such as stainless steel.

Citric acid dissociates through a series of steps:

$$H_3Ct(aq) + H_2O(\ell) \Leftrightarrow H_3O^+(aq) + H_2Ct^-(aq)$$
$$H_2Ct^-(aq) + H_2O(\ell) \Leftrightarrow H_3O^+(aq) + HCt^{2-}(aq)$$
$$HCt^{2-}(aq) + H_2O(\ell) \Leftrightarrow H_3O^+(aq) + Ct^{3-}(aq)$$

The K_a values for the three steps in the dissociation, in random order, are

I 7.0×10^{-4}
II 6.5×10^{-6}
III 1.8×10^{-5}

The K_a values for $H_3Ct(aq)$, $H_2Ct^-(aq)$, and $HCt^{2-}(aq)$, respectively, are

A. II, I, III
B. II, III, I
C. I, II, III
D. I, III, II

What is the $[H^+]$ in a 0.50 $mol \cdot L^{-1}$ solution of nitrous acid, HNO_2, which has a K_a value of 5.1×10^{-4}?

A. 1.6×10^{-2} $mol \cdot L^{-1}$
B. 1.2×10^{-5} $mol \cdot L^{-1}$
C. 5.1×10^{-4} $mol \cdot L^{-1}$
D. 2.6×10^{-4} $mol \cdot L^{-1}$

27. Acids and bases can be described using the terms strong, weak, dilute and concentrated. Which statement below is a correct use of the terms?

A. A strong acid cannot be dilute.
B. A weak acid cannot be concentrated.
C. The strength of acids varies during changes in concentration.
D. The strength of acids remains constant during changes in concentration.

29. What is the $[H_3O^+]$ in a 0.020 $mol \cdot L^{-1}$ solution of $Ca(OH)_2(aq)$?

A. 1.0×10^{-12} $mol \cdot L^{-1}$
B. 5.0×10^{-15} $mol \cdot L^{-1}$
C. 2.5×10^{-15} $mol \cdot L^{-1}$
D. 1.0×10^{-14} $mol \cdot L^{-1}$

What volume (in mL) of antacid, 0.015 M $Mg(OH)_2(aq)$, is required to neutralize 25 mL of stomach acid, 0.020 M $HCl(aq)$? Round your answer to the nearest whole number.